S
627.83
U11tdw
1981
Twodot Dam,
Wheatland County,
Montana, MT-1486

- INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

07

TWODOT DAM

WHEATLAND COUNTY, MONTANA
MT-1486

PREPARED FOR:

HONORABLE TED SCHWINDEN

GOVERNOR, STATE OF MONTANA

AND

FOX RANCH COMPANY

OWNER / OPERATOR

STATE DOCUMENTS COLLECTION
MAR 19 1991
MONTANA STATE LIBRARY
1515 E. 6th AVE.
HELENA, MONTANA 59620

PREPARED BY:

Christian, Spring, Sielbach & Associates

Bozeman, Montana

Assisted By:

Northern Testing Labs, Inc.

Great Falls, Montana

JULY 1981

Seattle District

United States

Army Corps of Engineers

PLEASE RETURN

MONTANA STATE LIBRARY
S 627.83 U11tdw 1981 c.1
Twodot Dam, Wheatland County, Montana, M
3 0864 00071602 0

TABLE OF CONTENTS

Paragraph		Page
	Executive Summary	i
	Pertinent Data	iv
CHAPTER 1 -	BACKGROUND	1
1.1	INTRODUCTION	1
1.1.1	Authority and Scope	1
1.1.2	Purpose	2
1.1.3	Inspection	2
1.2	DESCRIPTION OF PROJECT	3
1.2.1	General	3
1.2.2	Regional Geology - Twodot Dam	4
1.2.3	Seismicity	4
1.2.4	Site Geology	4
1.2.5	Design and Construction History	4
CHAPTER 2 -	INSPECTION AND RECORDS EVALUATION	5
2.1	HYDRAULICS	5
2.1.1	Outlet Works	5
2.1.2	Spillway	5
2.1.3	Freeboard	6
2.2	HYDROLOGY	6
2.2.1	Physiography and Climatology	6
2.2.2	Reservoir Storage and Spillway Discharge	7
2.2.3	Estimated Probable Maximum Flood (PMF)	7
2.2.4	Flood Routing	7
2.3	GEOTECHNICAL EVALUATION	8
2.3.1	Dam Embankment	8
2.3.2	Foundation Conditions, Seepage and Drainage	9
2.3.3	Stability	9
2.4	PROJECT OPERATIONS AND MAINTENANCE	9
2.4.1	Dam Maintenance Plan	9
2.4.2	Reservoir	9
2.4.3	Warning System	9
CHAPTER 3 -	FINDINGS AND RECOMMENDATIONS	10
3.1	FINDINGS	10
3.1.1	Size, Hazard Classification, and Dam Safety Evaluation	10
3.1.2	Low Level Outlet Works and Irrigation Outlet	10
3.1.3	Spillway	10
3.1.4	Reservoir Storage and Spillway Capacity	11
3.1.5	Dam Embankment	11
3.1.6	Stability	11
3.1.7	Operations and Maintenance	11
3.2	RECOMMENDATIONS	11
REFERENCES		13
Appendix A		

Digitized by the Internet Archive
in 2015

https://archive.org/details/twodotdamwheatla1981chri

TWODOT DAM

PHOTOS

Photo 1 Dam Crest & Downstream 2:1 Slope Looking West Towards Left Abutment

Photo 2 Upstream Slope

Photo 3 Wave Erosion Near Right Abutment

Photo 4 Low Level Outlet Works Outlet

Photo 5 Irrigation Outlet

Photo 6 Spillway Crest

Photo 7 Seepage Exit at Downstream Toe Near Right Abutment

Photo 8 Typical Animal Burrow on Downstream Slope

PLATES

Plate 1 Location Map

Plate 2 Drainage Map

Plate 3 Site Plan

Plate 4 Dam Section

Plate 5 Outlet Works

Plate 6 Irrigation - Outlet Works

Plate 7 Spillway

Plate 8 Rating Curve

EXECUTIVE SUMMARY

Personnel of Christian, Spring, Sielbach & Associates, principal contractor, and Northern Testing Laboratories, Inc., subcontractors, under a contract with the Montana Department of Natural Resources and Conservation (MDNRC) and with representation from the MDNRC and the owner, inspected the Twodot Dam on December 18, 1980, under the authority of Public Law 92-367. The project is located principally in Section 11, T7N, R13E, MPM, on Alkali Creek in Wheatland County, Montana, approximately 3 miles south of the town of Twodot, Montana.

This report was compiled from information obtained during the onsite inspection and analysis of available information. Findings were compared with engineering criteria that are currently accepted by most private and public agencies engaged in dam design, construction and operation.

Findings and Evaluation

The Twodot Dam was constructed about 1953. There are no available records of the engineering entity responsible for design and construction nor are construction plans available. The project is primarily used for storage of irrigation waters and is owned and operated by Fox Ranches, Inc.

The 31-foot-high Twodot Dam impounds approximately 650 acre-feet of water at dam crest elevation 4634.5 feet National Geodetic Vertical Datum (NGVD). All elevations are relative to the reservoir water surface assumed elevation 4630.0 feet NGVD taken during the inspection. On the basis of criteria in the U.S. Army Corps of Engineers Recommended Guidelines for Safety Inspection of Dams (Ref. 3), the project is small in size.

The sudden failure of Twodot Dam would cause flooding in the town of Twodot located about three miles downstream of the dam. Several residences, and commercial buildings could be severely damaged and there is a potential for loss of life. The conclusions on probable damage are based on a brief field visit and engineering judgment. No dam breach analysis or routing of a dam breach flood was made for the dam. In accordance with inspection guidelines, the project is classified as having a high (Category 1) downstream hazard potential.

Inspection criteria (Ref. 3) recommend that the spillway design flood (SDF) for a small size project with a high downstream hazard potential be in the range of ½ the probable maximum flood (PMF) to a full PMF. The PMF is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region. Because of the assessed downstream risk, we recommend that the project safely handle one-half the PMF. The estimated PMF for the 11.5 square mile drainage basin resulted from a 72-hour general storm probable maximum precipitation (PMP) developed for this dam safety study. The resultant PMF has an estimated volume of 14,330 acre-feet and a peak flow of 47,100 c.f.s. The estimated maximum capacity of the spillway with the reservoir at dam crest elevation 4534.5 feet NGVD is 1,000 c.f.s. Routing of the estimated PMF indicates that Twodot Dam is overtopped when only 3 percent of the total PMF flood volume enters the reservoir. Routings of lesser

hypothetical floods made by applying percentages to the PMF hydrograph ordinates, showed that a flood corresponding to 3 percent PMF hydrograph ordinates is just controlled by the project. The dam is constructed of materials that would erode and fail when overtopped by flood waters.

The visual inspection revealed no signs of cracking or unusual settlement in the dam embankment. The upstream slope has some wave erosion damage. Riprap above the water level in the reservoir (El. 4630.0 NGVD) at the time of inspection was scattered or non-existent on a large part of the upstream slope. The downstream slope has some minor slough areas. Substantial seepage was apparent at the foundation-embankment contact of the downstream toe of the dam. A flowing seep observed near the right abutment has caused some sloughing, which could lead to progressive failures into the downstream toe of the embankment.

There is insufficient data on seepage, position of the phreatic surface, and strength of embankment and foundation materials to accurately assess the stability of the embankment.

Because of the small size of the low level outlet and high level irrigation outlet conduits, consisting of 18-inch-diameter, and 15-inch-diameter corrugated metal pipe respectively, a complete inspection of outlet pipes was not made at the time of the inspection. However, the low level outlet pipe showed signs of corrosion at the invert of the outlet end and there was a small flow of water exiting from the pipe. The gate-hoist base arrangement for the handwheel lift mechanism appear to be inadequate to prevent movement during operation. Since the gates were in a closed position, with the reservoir full, no attempt was made to operate the gates. However, we were assured by Charles Martins, Ranch Foreman that they were operable.

Because the project is capable of controlling only 3 percent of the probable maximum flood (PMF) developed for this inspection and significant seepage accompanied with minor sloughing is evident at the embankment and foundation contact at the downstream toe, Twodot Dam does not meet inspection guideline criteria to safely handle the recommended spillway design fllod. It is our judgement that the present spillway capacity is critically inadequate and structural modifications to increase the spillway capacity to safely pass the recommended spillway design flood are urgently needed to enhance project safety.

Recommendations

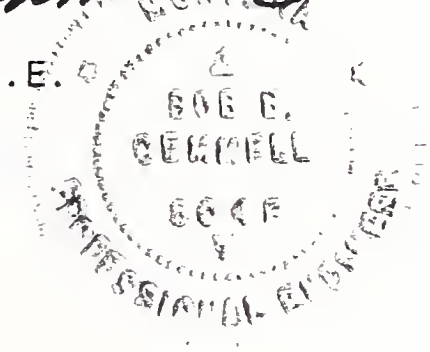
The intent of the report recommendations is to maintain or improve project safety. A downstream warning plan for use in the event of impending dam distress must be developed, tested and placed in action. Inspect the irrigation outlet conduits, gates and lifts, and repair as required. Repair slough areas and add filter protection at seepage exits near the downstream toe of embankment, using a properly graded aggregate filter. Repair wave erosion damage on the upstream slope and provide effective, durable riprap to protect against wave erosion.

Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity. Modify the project as studies indicate. Conduct and place on file, a

stability analysis of the dam embankment. Establish material strength properties by drilling and sampling with laboratory testing as appropriate. Investigate seepage paths and position of the phreatic surface. Modify the dam embankment and provide seepage control as studies indicate. Provide for inspection by qualified engineers at frequent intervals following modification, at least once a year for two years and at least at 5 year intervals thereafter.

Prior to performing engineering studies and remedial construction, coordinate the work with the State of Montana Department of Natural Resources and Conservation to insure compliance with all pertinent laws and regulations.

Bob B. Gemmell, P.E.



TWODOT DAM
PERTINENT DATA

1. General	
Federal I.D. No.	MT-1486
Owner/Operator	Fox Ranch Co.
Date Constructed	1953
Purpose	Irrigation
Location	Sec. 11, T7N, R13E, MPM 3 miles south of Twodot, Montana Latitude 46°23' Longitude 110°4'
County, State	Wheatland, Montana
Watershed	Alkali Creek a tributary of the Musselshell River
Drainage Area	11.5 square miles
Size Classification	Small
Downstream Hazard Classification	Category 1 (High)
2. Reservoir	
Surface area at Normal Pool El. 4630 ft. NGVD	42 acres
Storage at Spillway Crest El. 4632.2 ft. NGVD	555 acre-feet
Storage at Dam Crest El 4634.5 NGVD	650 acre-feet
Surcharge Storage	95 acre-feet
Reservoir Level 12/80	4,630 ft. NGVD
3. Low Level Drawdown Outlet	
Type	18 inch corrugated metal pipe w/slide gate on upstream end and gate control on dam crest.
Conduit Length	est. 170 ft.
Capacity with Reservoir at dam crest	28 c.f.s.
Inlet Elevation	est. 4605. ft. NGVD
4. Irrigation Outlet Works	
Type	15 inch spiral corrugated metal pipe w/slide gate on upstream end and gate control on dam crest.
Conduit Length	est. 60 ft.
Capacity with Reservoir at dam crest	15 c.f.s.
Inlet Elevation	4624.0 ft. NGVD
5. Spillway	
Type	Uncontrolled natural earth saddle parabolic shaped
Crest Elevation	4632.2 ft. NGVD
Crest Length	200 feet (wetted perimeter)
Capacity with Reservoir at dam crest	1,000 c.f.s.

TWODOT DAM
PERTINENT DATA
(Continued)

6. Dam Embankment

Type	Earth Fill
Hydraulic Height	31 feet
Crest Width	15 feet
Crest Length	750 feet
Crest Elevation (low point)	4634.5 ft. NGVD
Upstream Slope	variable, unconfirmed
Downstream Slope	Varies 1V on 1.7H to 1V on 2.0H

CHAPTER 1
BACKGROUND

1.1 INTRODUCTION

1.1.1 Authority and Scope

This report summarizes the Phase I inspection and evaluation of the Twodot Dam, near the town of Twodot in Wheatland County, Montana. The project is owned and operated by the Fox Ranch Company.

The National Dam Inspection Act, Public Law 92-367 dated 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers to conduct safety inspections on non-federal dams throughout the United States. Pursuant to that authority, the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" in Appendix D, Volume 1 of the U.S. Army Corps of Engineers' Report to the United States Congress on "National Program of Inspection of Dams" in May, 1975 (Ref. 3).

The recommended guidelines were prepared with the help of engineers and scientists highly experienced in dam safety from many federal and state agencies, professional engineering organizations and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive consensus of the engineering community.

Where necessary the guidelines recommend a two-phase study procedure for investigating and evaluating existing dam conditions so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

(1) a limited investigation to assess the general safety and condition of the dam.
(2) based upon an evaluation of the available data and a visual inspection.
(3) performed to determine if any needed emergency measures and/or if additional studies, investigations and analyses are necessary or warranted.
(4) not intended to include extensive explorations, analysis or to provide detailed alternative corrective recommendations.

The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam. Included in Phase II, as required, should be additional visual inspections, measurements, foundation exploration and testing, material testing, hydraulic and hydrologic analyses and structural stability analyses.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations with the exception of situations of extreme emergency. In these cases the Corps may proceed with Phase II studies but only to the extent needed to answer serious questions relating to dam safety that cannot be answered otherwise. The two phases of investigation outlined above are intended

only to evalute project safety and do not encompass in scope the engineering required to perform design or corrective modification work. Recommendations contained in this report may be for either Phase II safety analyses or detailed design study for corrective work.

The responsibility for implementation of these Phase I recommendations rests with the dam owner. It should be noted that nothing contained in the National Dam Inspection Act, and action or failure to act under this Act shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership and operation of the dam.

1.1.2 Purpose

The purpose of the inspection and evaluation is to identify current physical and operational conditions of the dam and appurtenances; and to determine if emergency measures and/or additional studies, investigations, and analyses are needed, so that corrections can be made in a timely manner by non-federal interests.

1.1.3 Inspection

The findings and recommendations in this report were based on a review of available engineering data, records and a visual inspection of the project. Design information and construction drawings were unavailable. Inspection procedures and criteria used for this report were those established by the Recommended Guidelines for the Safety Inspection of Dams. (Ref. 3)

The inspection was conducted jointly by personnel from Christian, Spring, Sielbach & Associates and Northern Testing Laboratories, Inc., subcontractors. Personnel who participated in the field inspection and contributed to this report were:

CSSA- Bob B. Gemmell, Engineer, Team Leader
Alfred Cunningham, Hydraulics/Hydrology (report only)
Les Crawford, Civil Engineer (report only)

NTL- Robert Gillespie, Geotechnical Engineer (report only)
Bill Henning, Geologist
Gary Quinn, Geotechnical Engineer

MDNRC- Montana Department of Natural Resources and Conservation
Art Taylor, Dam Safety Engineer

Other personnel present and participating in the field inspection include:

Charles Martins, Fox Ranches, Inc.

This report has been reviewed by The Fox Ranch Company and the State of Montana DNRC and their written comments are enclosed in Appendix A.

1.2 DESCRIPTION OF PROJECT

1.2.1 General

a. Location, Owner and Purpose

Twodot Dam is located on Alkali Creek in Section 11, Township 7 North, Range 13 East, MPM, in Wheatland County, Montana. (Plate 1) The reservoir impoundment is formed by a dam with both an irrigation and a low level outlet works. The reservoir is less than three miles south of the town of Twodot (Plate 2). The Federal identification number for Twodot Dam is MT-1486. The dam is listed as having a high (Category 1) downstream hazard potential.

The dam is owned and operated by the Fox Ranch Company. The project was planned for use as an irrigation storage and diversion. It is not reliably known who designed the project or who provided construction management services when the project was constructed in about 1953.

b. Description of Dam and Appurtenances

The Twodot Dam appears to be a rolled earth-fill structure using soil materials primarily from local borrow areas. The dam embankment has a height of 31 feet from downstream toe to dam crest. All elevations in this report are relative to an assumed elevation of 4630.0 feet NGVD at the water surface at the time of inspection. The dam crest is generally at 4636.0 feet NGVD with a low elevation of 4634.5 feet NGVD. This is the lowest point in the reservoir boundary and is therefore used as dam crest throughout this report. The reservoir will impound 650 acre-feet at dam crest elevation 4634.5 feet and 555 acre-feet at spillway crest elevation 4632.2 feet. The surface area of the reservoir at normal pool El. 4630.0 feet is 42 acres. The drainage basin is approximately 11.5 square miles.

There are two controlled outlets. One, a low level drawdown-outlet works is an 18-inch corrugated metal pipe and is located near the center of the dam with an outlet at an elevation of about 4605 feet NGVD. The other, an irrigation outlet is a 15-inch spiral corrugated metal pipe and is located near the right or east abutment. Both conduits have slide gates mounted on their inlets with handwheel controls on the upstream shoulder of dam crest.

The spillway is a roughly parabolic shaped natural saddle located at the southwest corner of the reservoir. A small knoll separates the emergency spillway from the dam embankment. The grass covered crest has a bottom elevation of 4632.2 feet NGVD at the low point in the section. The downstream channel is crossed by an access road with a 36-inch CMP culvert. The downstream channel leads to Fox Reservoir about ½ mile downstream. Fox Reservoir in turn discharges into the Musselshell River and does not appear to endanger the town of Twodot.

c. Hazard Potential

Based on visual reconnaissance and engineering judgment, Twodot Reservoir is located such that a sudden breach of the dam could endanger lives and cause extensive property damage in the downstream area (Plate 2). Several residences and commercial buildings would be affected in the small community of Twodot. On the basis of this information and in accordance with recommended guidelines, the Twodot project's size is small and the downstream hazard potential is high (Category 1).

1.2.2 Regional Geology - Twodot Dam

Sedimentary rocks of Paleozoic to early Cenezoic age are exposed in the Twodot region. This long interval of quiet deposition was followed by intrusive igneous activity and associated uplift in late Cretaceous to early Tertiary time. Subsequent later erosion and deposition of later Tertiary sediments of gravel, sand, silt, and clay has produced much of the present topography.

1.2.3 Seismicity

The site lies in a thin strip mapped as Seismic Zone 2, a zone of generally moderate seismic risk, in the Corps of Engineers Guidelines. This zone is bordered by one of potentially major seismic activity in the uplifted and intruded regions to the west. A seismic coefficient of 0.05 is appropriate for the site.

Preliminary seismic mapping by Algermissen and Perkins indicates there is a 90 percent probability that the horizontal acceleration in rock will not exceed 0.04g in a given 50-year period.

1.2.4 Site Geology

Twodot Dam lies across a north-south-trending valley, formed by downcutting of Alkali Creek through the soft, upper Cretaceous sandstone and shale formations.

Both abutments and most of the foundation are soft sandstone and shale of the Claggett or Judith River Formations. These bedrock units are nearly horizontal, with some minor folding observed on the left abutment. The sandstone and shale units weather easily, forming low, rounded hills on the abutments and surrounding area. The dam rests on alluvium in its middle section, with the alluvium extending to an unknown depth.

1.2.5 Design and Construction History

The Twodot Dam was constructed about 1953. There are no available records of the engineering entity responsible for design and construction nor are construction plans available. The project is primarily used for storage of irrigation waters and is owned and operated by Fox Ranches, Inc.

CHAPTER 2
INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS

2.1.1 Outlet Works

Twodot Reservoir has two controlled outlets. The low level drawdown outlet is located near the center of the dam embankment. It consists of a 170 foot long, 18-inch-diameter corrugated metal pipe (CMP) through the embankment with the discharge invert at about elevation 4603.2 feet NGVD (Plate 5 and Photo 4). An inlet mounted slide gate with handwheel lift on the dam crest, controls discharges from the reservoir back into Alkali Creek. The maximum discharge of the outlet works is estimated to be 28 c.f.s. with the reservoir at dam crest 4634.5 feet NGVD. A Mannings "n" of 0.025 was used to estimate friction losses with the conduit flowing full.

The higher level irrigation outlet is a 15-inch-diameter spiral corrugated metal pipe (SCMP) located in the embankment near the right or east abutment. The 60-foot long SCMP is at invert elevation 4624.0 feet NGVD, and empties into an irrigation canal. It also has an inlet mounted slide gate with a handwheel lift control at the dam crest. The maximum discharge of this irrigation outlet into the downstream open channel conveyance canal was estimated to be 15 c.f.s. with the reservoir at the dam crest. A Mannings "n" of 0.025 was used to estimate friction losses in a full flowing conduit.

At the time of inspection both slide gates were submerged and could not be visually inspected.

The low level drawdown gate was in a closed position and appeared to be in working order. Some minor leakage was observed at the outlet of the pipe. It could not be determined if water was coming from a leaking gate or was somehow related to the CMP condition. Minor corrosion with loss of metal was observed at the invert of the pipe's exposed outlet end. The high level irrigation outlet gate was also closed. The hoist base for the handwheel lift on both gate lift mechanisms appeared to be inadequate to prevent rotational movement during lift operation. Because the reservoir was full, and there appeared to be a potential for binding in an open position with subsequent loss of water during the non-use winter months, no attempt was made to operate gates at the time of inspection. However, Mr. Martins assured the inspection team that the gates were operable. Due to the small size of outlet pipes, a complete inspection could not be made. Since neither outlet shows signs of serious erosion, the installation of the outlets appears satisfactory.

2.1.2 Spillway

The spillway is a natural grassy saddle, located in the southwest portion of the reservoir, approximately 1,200 feet south of the left abutment of the dam. The entrance to the spillway is parabolic in cross-section, with the low point or crest at El. 4632.2 feet NGVD. The gradient of the exit channel downstream from the crest is approximately 0.01 for a distance of 100 feet, and 0.04 for the next 100 feet. A 36-inch-diameter

CMP culvert serving an access road crossing the spillway channel is located approximately 100 feet downstream from the spillway crest. Very low flows in the exit channel would be controlled by the culvert. High flows would inundate the roadway which is lower than the spillway crest, without backwater effects on the spillway crest. The spillway crest would have a wetted perimeter of approximately 200 feet when flowing with the water surface at dam crest.

The exit channel leads to Fox Reservoir, a holding reservoir about ½ mile downstream. The discharge rating curve for the spillway was computed with the aid of the Corps of Engineers HEC-2, Water Surface Profiles, Computer Program (Ref. 5). A channel roughness coefficient (Mannings "n") of .030 was assumed for the exit channel. A uniform cross-section with bottom gradients as shown in profile on Plate 7 was assumed. Water surface profiles were computed for discharges ranging from 100 c.f.s. to 3,000 c.f.s. The calculated discharge with the reservoir at dam crest El. 4634.5 feet NGVD was estimated to be 1,000 c.f.s.

The spillway operates annually to provide water to the Fox holding reservoir. The well grassed spillway shows little signs of erosion.

2.1.3 Freeboard

Routings indicate that the dam overtops before 3% of the estimated probable maximum flood (PMF) volume enters the reservoir (see paragraph 2.2.4), therefore there is no freeboard with the recommended spillway design flood. At the time of inspection the reservoir was at an elevation approximately two feet below the spillway crest elevation 4632.2 feet NGVD. The vertical distance between the low point on the dam crest and reservoir level at the time of inspection was approximately 4.5 feet. The highest historical lake level appears to be at about elevation 4633.0 feet NGVD. Wind generated waves could potentially overtop the low point in the dam embankment when the reservoir is operated at the maximum pool elevation. The maximum fetch is about 1,000 feet for the reservoir and wave run-up was estimated to be less than 2 feet.

2.2 HYDROLOGY

2.2.1 Physiography and Climatology

The Twodot Dam and Reservoir are located at Latitude 46°23', Longitude 110°4' near the town of Twodot in Central Montana. The elevation of the low point of the dam crest is 4634.5 feet NGVD. The reservoir is located on Alkali Creek and serves primarily as a water supply for irrigated areas downstream. The site is located in what is commonly known as the Foothills region of Montana, which is characterized by large, rolling hills with occasional stands of timber.

The climate of this region of Montana is commonly considered "Continental" and therefore typical for the interior of a large land area. Weather in this region is highly variable with rapid changes brought on by the invasion of large air masses from the Gulf of Mexico, the south and southwest, the north Pacific Ocean, and Polar Region (Ref. 1). Montana is in the westerly wind belt throughout the year with the result that much of its weather comes from the North Pacific. Temperature variation in the

Twodot Dam vicinity is extreme with summer highs in the upper nineties and winter lows down to about minus 30°F. The average "freeze-free season" for the Twodot location is about 70 days indicating that frozen ground conditions are possible most of the year. Average annual precipitation at this site ranges from 10-14 inches with heavy amounts possible during summer thunderstorms. Annual average lake evaporation at this site is about 40 inches.

2.2.2 Reservoir Storage and Spillway Discharge

The reservoir has a storage of 555 acre-feet at the spillway crest and 650 acre-feet at the top of dam, thereby providing 95 acre-feet of surcharge storage. The spillway capacity is about 1,000 c.f.s. at dam crest El. 4634.5 feet NGVD.

2.2.3 Estimated Probable Maximum Flood (PMF)

The probable maximum flood (PMF) is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region.

The PMF for Twodot reservoir was developed using the HEC-1 Flood Hydrograph Dam Safety Computer Program (Ref. 4). Primary program input consisted of the 72-hour probable maximum precipitation (PMP) which was obtained for the study site from Ref. 2. The 24-hour 10-sq. mile PMP value was determined from Figure 1 in Ref. 2 to be 19.00 inches. PMP values for durations of 1, 2, 3, 4, 5, 6, 12, 24, 48-and 72-hours were also determined from Ref. 2 and used to plot a depth-duration curve. This curve was used to find one hour incremental PMP values which were subsequently arranged in their critical sequence according to Ref. 7. Total precipitation for the 72-hour period was 23.56 inches and the maximum hourly value was 8.65 inches.

The unit hydrograph for the 11.5 square mile Twodot drainage basin was developed based on the SCS unit hydrograph procedure (Ref. 6). The time of concentration from the basin was estimated to be 1.6 hours and the basin lag was computed to be .95 hours. An incremental storm interval of 10 minutes was chosen which corresponds to approximately one-sixth of the basin lag.

Combination of the critical PMP sequence with the unit hydrograph ordinates resulted in the PMF inflow hydrograph to Twodot Reservoir. It was assumed that frozen soil conditions prevailed during the PMF therefore the infiltration rate was zero. The resulting PMF peak inflow to Twodot Reservoir was found to be 47,170 c.f.s. while the total inflow volume was 14,330 acre-feet.

2.2.4 Flood Routing

Routing of the estimated PMF hydrograph through Twodot Reservoir was accomplished by means of computer program HEC-1 (Ref. 4). Initial reservoir surface elevation was assumed to be at the spillway crest El. 4632.2 feet NGVD, at the onset of the PMF while initial inflow as well as infiltration were assumed to be zero. The modified puls method was used for reservoir routing.

Routing studies indicated that Twodot Dam will successfully pass a flood having hydrograph ordinates approximately equal to 3% of the PMF hydrograph ordinates. Any larger flood will cause the dam to overtop.

2.3 GEOTECHNICAL EVALUATION

The Twodot Dam closes Alkali Creek Valley, carved through the weathered sandstone and shale formations. The drainage is tributary to the Musselshell River.

A plan view of the dam site and reservoir is shown on Plate 3, and approximate embankment cross sections are shown on Plate 4. There are no records of foundation investigation or stability analysis. Plans and specifications were not available, and there are no records or indications that the embankment performance has been monitored.

2.3.1 Dam Embankment

The dam has a length of approximately 750 feet and reaches a maximum height of 31 feet. Crest width is typically about 15 feet. The reservoir level was approximately 5 feet below the dam crest at the time of inspection. Embankment materials appear to be a heterogeneous mixture of alluvium and weathered shale and sandstone. The alluvial materials are graded from clay to gravel.

The dam crest shows no settlement, misalignment, or cracking (Photo 1). The service road crossing the crest is not surfaced; some minor rutting has resulted (Photo 2).

The upstream slope appears to have had a design slope of about 1V on 3H (Plate 4), however this could not be confirmed. This slope has been interrupted by wave erosion of variable extent along most of its length. The greatest erosion has occurred over about a 50-foot section near the midpoint of the dam, where there is a vertical cut of about 5 feet off the crest shoulder (Photo 3 and Plate 4). Riprap protection, consisting primarily of volcanic and sandstone boulders, covers approximately the lower one-half of the exposed slope (Photo 2). Some concrete rubble riprap was observed near the right abutment. There is scattered brush on portions of the slope above the riprap. Excepting wave erosion damage, no cracking or other slope irregularities were observed. Since the reservoir water level was at elevation 4630.0 feet NGVD at the time of inspection, the upstream slope could not be completely examined.

The downstream slope is approximately 1V on 2H (Plate 4), and there is no evidence of cracking or settlement (Photos 1 and 4). There is some minor sloughing due to runoff erosion. Some animal burrows were noted (Photo 8). Near the right abutment the downstream slope steepens to approximately 1V on 1.7H (Photo 5).

There was no seepage observed exiting the downstream slope. However, the downstream toe area was wet and two substantial areas of seepage were located (Photo 7) (see paragraph 2.3.2).

The abutment contacts are both sound. The left abutment appears to be folded shale with sandstone layers, while the right abutment consists

predominantly of sandstone with interbedded shale. Portions of the embankment materials appear to have been borrowed from the left abutment area.

2.3.2 Foundation Conditions, Seepage, and Drainage

The weathered sandstone and shale materials observed at the abutments were downcut across the valley floor and later covered by alluvial valley fill. The valley fill materials are sorted deposits of silt, sand, and gravel.

The broad, downstream Alkali Creek Valley is generally poorly drained with some marshy areas even on higher benches. It appears that there is substantial underflow through the valley fill alluvium. It is not known if there was a cutoff trench beneath the dam.

The downstream toe area is wet. Substantial seeps were noted approximately 175 feet left of the right abutment in the old channel area, and about 400 feet right of the left abutment (Plate 3). The seepage in both cases exits immediately beyond the downstream toe at the embankment-foundation interface. The seep nearest the right abutment, flowing at a rate of about 10 gallons per minute, has caused some erosion and sloughing at its exit (Photo 7). At the time of inspection the seepage water was clear. Flow was not observed in the seepage areas nearest the left abutment. There was no visible boiling in the toe area.

2.3.3 Stability

At the time of inspection there was no evidence indicating mass instability. However, this judgment is not supported by a stability analysis, nor is there sufficent data available to make one. Unattended seepage near the right abutment in the old channel area may continue to aggravate downstream sloughing.

2.4 PROJECT OPERATIONS AND MAINTENANCE

2.4.1 Dam Maintenance Plan

Project maintenance inspections have not been made on a regular basis and no records or published maintenance plans were available for review. Maintenance has been performed by the owner as needed as a part of normal operating procedures.

2.4.2 Reservoir

Pool levels fluctuate with the irrigation season requirements. Normal maximum pool elevation is 4632.5 feet NGVD. Overflow is used to fill Fox Reservoir. Minimum pool elevation was estimated at 4605 feet NGVD. Reservoir records were not available for review.

2.4.3 Warning System

There is no downstream warning plan in case of impending dam failure.

CHAPTER 3
FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS

Visual inspection of the dam, supplemented by analysis of available engineering data for the project in terms of the Guidelines (Ref. 1) resulted in the following findings.

3.1.1 Size, Hazard Classification and Dam Safety Evaluation

The 31-foot-high dam impounds about 650 acre-feet of water with the reservoir at dam crest. In accordance with inspection guidelines, (Ref. 3), Twodot Dam is small in size and based on our visual inspection and engineering judgment, it has a high downstream hazard potential. The guidelines recommend that a dam with the above classification be capable of safely handling one-half to the full PMF. Because of the assessed downstream risk we recommend that the project safely handle a spillway design flood equal to 1/2 the PMF. The dam overtops during the PMF when approximately 3% of the PMF volume enters the reservoir. The project can just control a flood having hydrograph ordinates of 3% of the PMF hydrograph ordinates developed for this study. Because the project is incapable of handling a flood having one-half the PMF ordinates without overtopping and causing the dam to fail, and significant seepage problems exist, Twodot Dam does not conform to the recommended guidelines. More detailed hydrologic and hydraulic routing studies are required to better determine the downstream hazard potential and the magnitude of the recommended Spillway Design Flood (SDF). Project modifications are needed to enhance the safety of the project.

3.1.2 Low Level Outlet Works and Irrigation Outlet

The low level outlet works is an 18-inch-diameter CMP with a slide gate on its inlet. The inlet was submerged at the time of inspection and it's condition could not be visually determined. The slide gate was in a closed position at the time of the inspection, however, some leakage was noted at the pipe outlet. It could not be determined whether leakage was associated with the slide gate or was seeping through the pipe conduit. Some corrosion was noted at the invert of pipe at the outlet end.

The irrigation outlet is a 15-inch-diameter SCMP also with a slide gate on its inlet. The condition of the inlet was unverifiable again due to the reservoir levels. Because of potential for binding in an open position at high heads, no attempt was made to operate gates, during this inspection. Due to small size, a complete inspection of pipe conduits was not made. The gates, gate lift mechanisms, and conduits should be thoroughly inspected at an early date.

3.1.3 Spillway

The spillway is a parabolic shaped saddle located in the southwest corner of the reservoir. The 200-foot wide crest (wetted perimeter) is lined with native grasses and shows signs of passing about 1 to 2 feet of water every year. There were no visible irregularities and the spillway appeared to generally be in good condition with a good covering of native grasses.

3.1.4 Reservoir Storage and Spillway Capacity

The reservoir has a surface area of about 42 acres and a storage of approximately 555 acre-feet at spillway crest elevation 4632.2 feet NGVD. Approximately 95 acre-feet of surface storage is available between the spillway crest and minimum dam crest elevation 4634.5 feet NGVD. The discharge capacity of the uncontrolled spillway is 1,000 c.f.s. with the reservoir at minimum dam crest. The low level outlet has an estimated capacity of 28 c.f.s. and the irrigation outlet has a capacity of 15 c.f.s., with the reservoir at dam crest.

3.1.5 Dam Embankment

There is no evidence of cracking or differential movement in the dam embankment.

The upstream slope has some wave erosion damage, the most serious of which is about a 50-foot section near the middle of the embankment. There is no riprap on the upper reaches of the slope. Since the reservoir water level was at El. 4630 feet NGVD at the time of inspection, the majority of the slope and wave protection (riprap) could not be inspected.

The downstream slope has some minor slough areas. Substantial seepage was apparent immediately beyond the downstream toe at the embankment-foundation contact. A flowing seep at about 175 feet left of the right abutment has caused some sloughing. The source of the seepage is probably underflow in the valley fill alluvium.

3.1.6. Stability

The seepage exiting near the right abutment has resulted in localized sloughing which could lead to progressive failures into the downstream slope. There is not sufficient embankment, foundation, or seepage data available to accurately assess the stability of the dam.

3.1.7 Operations and Maintenance

Normal pool elevation is maintained at or near the spillway crest by either irrigation outlet or spillway discharges. The low level outlet gate remains in a closed position and is rarely opened or tested. No formal operations plan for the reservoir exists. Maintenance is performed by the Fox Ranch Company personnel as required. There is no formal warning plan for use in the event of impending dam failure.

3.2 RECOMMENDATIONS

The intent of report recommendations is to improve project safety.

1. Immediately develop, implement, and periodically test an emergency warning plan for use in the event of impending dam distress.

2. Inspect the outlet conduits, gates and gate lift mechanisms, and repair as required.

3. Provide a properly graded aggregate filter for the downstream toe area at the seepage exit about 175 feet left of the right abutment, and at other seepage areas as appropriate.

4. Repair wave erosion damage on the upstream slope and provide filter and riprap protection for the uncovered slope face.

5. Reseed barren areas on the downstream slope.

6. Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and the required spillway capacity. Modify the project as studies indicate.

7. Conduct and place on file, a stability analysis of the dam embankment. We recommend this analysis be performed by a qualified geotechnical engineer based on: static loading conditions; in situ strength properties of the embankment, foundation, and abutment materials; and phreatic surface conditions. Establish the material strength properties by drilling and sampling with laboratory testing as appropriate. Determine the phreatic surface from piezometers installed in the borings. Modify the project as studies indicate.

8. Provide for inspection by qualified engineers at 1 year intervals for the first 2 years following modification and at intervals not to exceed 5 years thereafter. Prior to performing engineering studies and remedial construction, coordinate the work with the State of Montana Department of Natural Resources and Conservation to insure compliance with all pertinent laws and regulations.

REFERENCES

1. Montana Department of Natural Resources and Conservation, "The Framework Report," Vol. 1, October 1976.

2. National Weather Service, "Interim All-Season Probable Maximum Precipitation Estimates, Missouri River Basin West of 105th Meridian," January, 1980.

3. U.S. Army Corps of Engineers, Office the Chief of Engineers Report to the U.S. Congress, National Program of Inspection of Dams, Vol. 1, Appendix D, "Recommended Guidelines for Safety Inspection of Dams," Washington, D.C.; Department of the Army, May 1975.

4. U.S. Army Corps of Engineers, "Flood Hydrograph Package (HEC-1)," Hydrologic Engineering Center, Davis, CA.

5. U.S. Army Corps of Engineers, "Water Surface Profiles (HEC-2)," Hydrologic Engineering Center, Davis, CA, 1976.

6. U.S.D.A Soil Conservation Service, "National Engineering Handbook," Section 4, Hydrology.

7. U.S. Weather Bureau, "Hydrometeorological Report No. 43 - Probable Maximum Precipitation Northwest United States," Nov. 1966.

PHOTO 1

Dam Crest & Downstream 2:1 Slope

Looking West Towards Left Abutment

PHOTO 2

Upstream Slope

Note: Gate Handwheel for Irrigation Outlet

PHOTO 3

Wave Erosion Near Right Abutment

PHOTO 4

Low Level Outlet Works Outlet

PHOTO 5

Irrigation Outlet

Note: Area of 1.7:1 Slope On Dam Embankment

PHOTO 6

Spillway Crest

Note: Conduit is for Roadway Downstream from Crest

PHOTO 7

Seepage Exit At Downstream Toe Near Right Abutment

PHOTO 8

Typical Animal Burrow on Downstream Slope

MONTANA

PROJECT LOCATION

PLATE 1

TWO DOT DAM LOCATION MAP

0 5 10 20 30 40

SCALE IN MILES

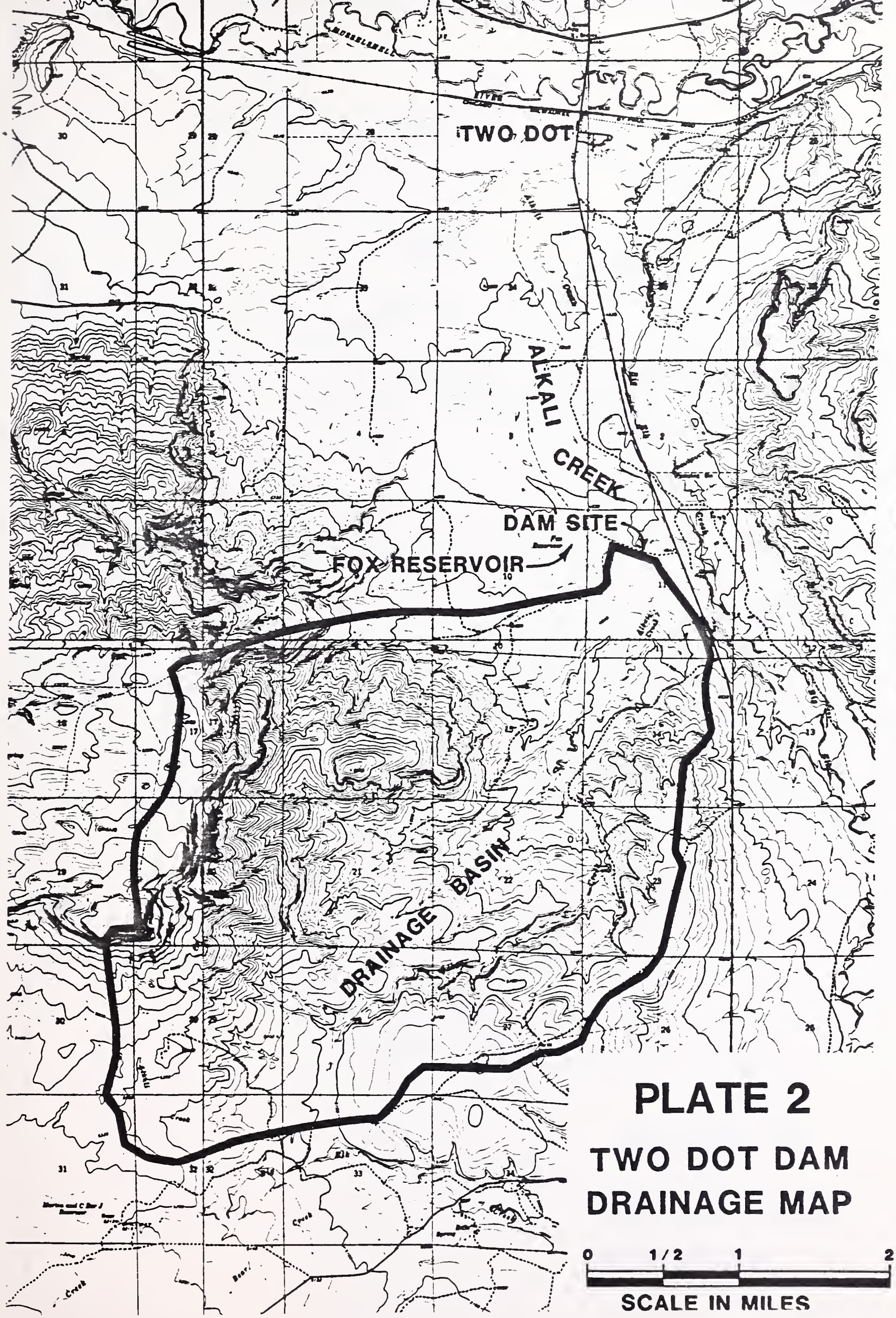


PLATE 2

TWO DOT DAM
DRAINAGE MAP

0 1/2 1 2

SCALE IN MILES

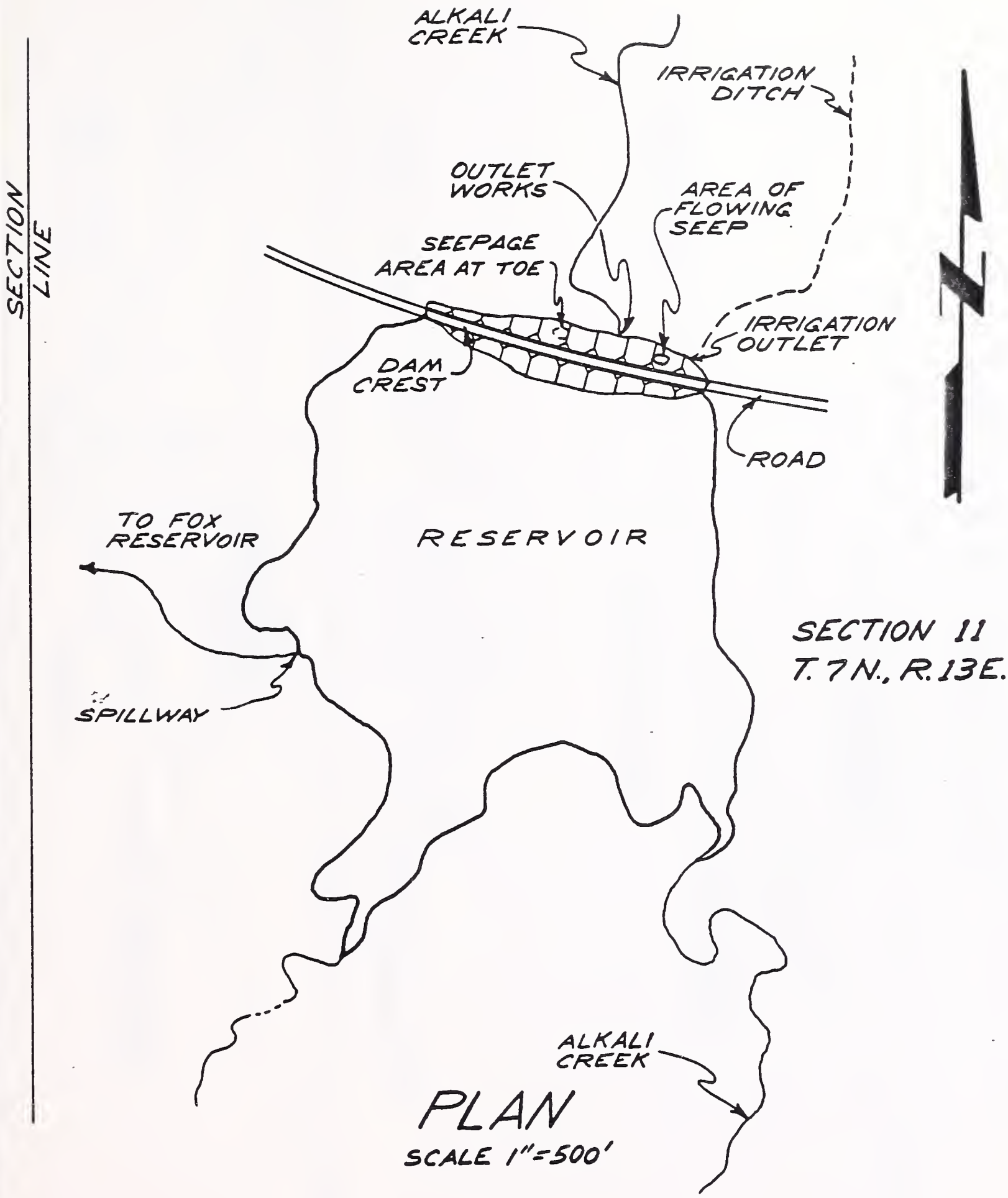
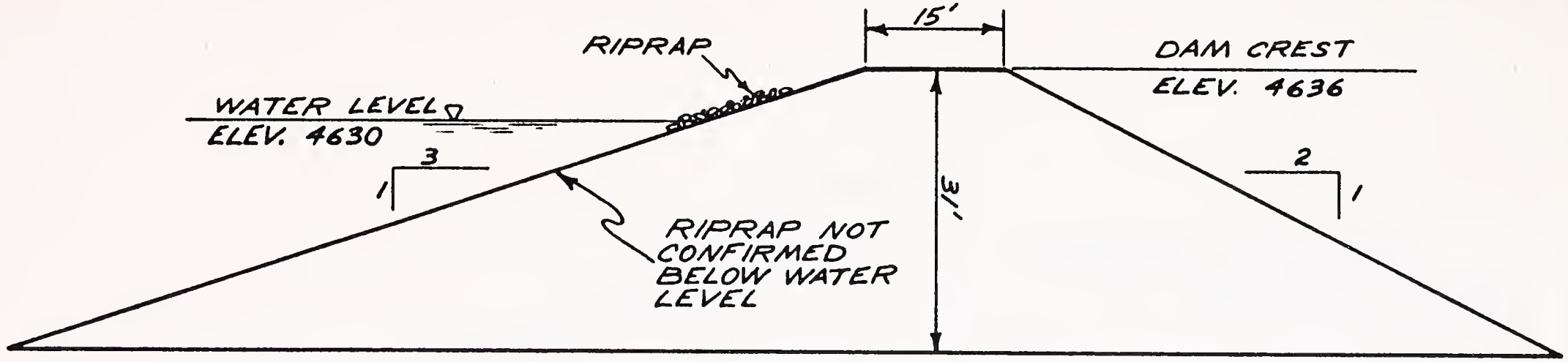


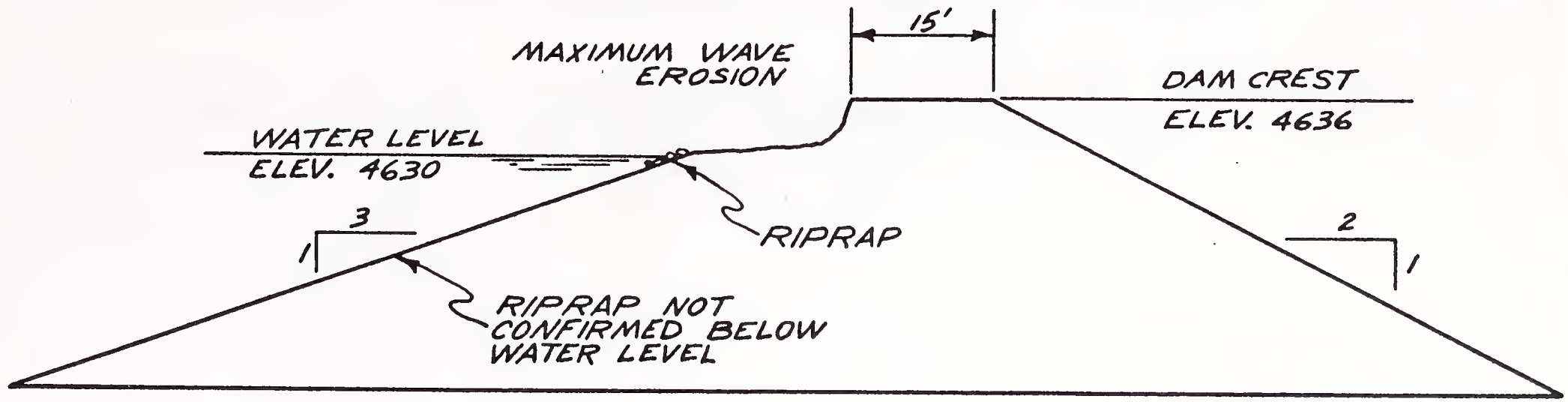
PLATE 3

TWO DOT DAM

SITE PLAN



APPROXIMATE ORIGINAL DAM SECTION
AT MAXIMUM HEIGHT
SCALE 1" = 20'

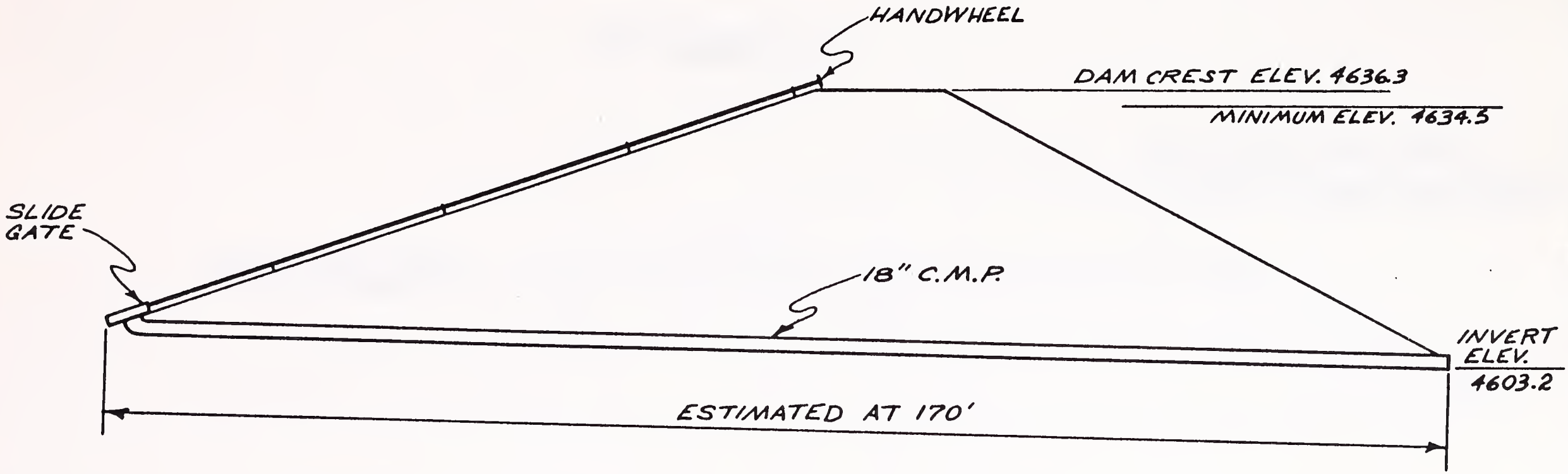


EXISTING DAM SECTION
AT LOCATION OF MOST SEVERE EROSION
SCALE 1" = 20'

PLATE 4

TWO DOT DAM

DAM SECTION



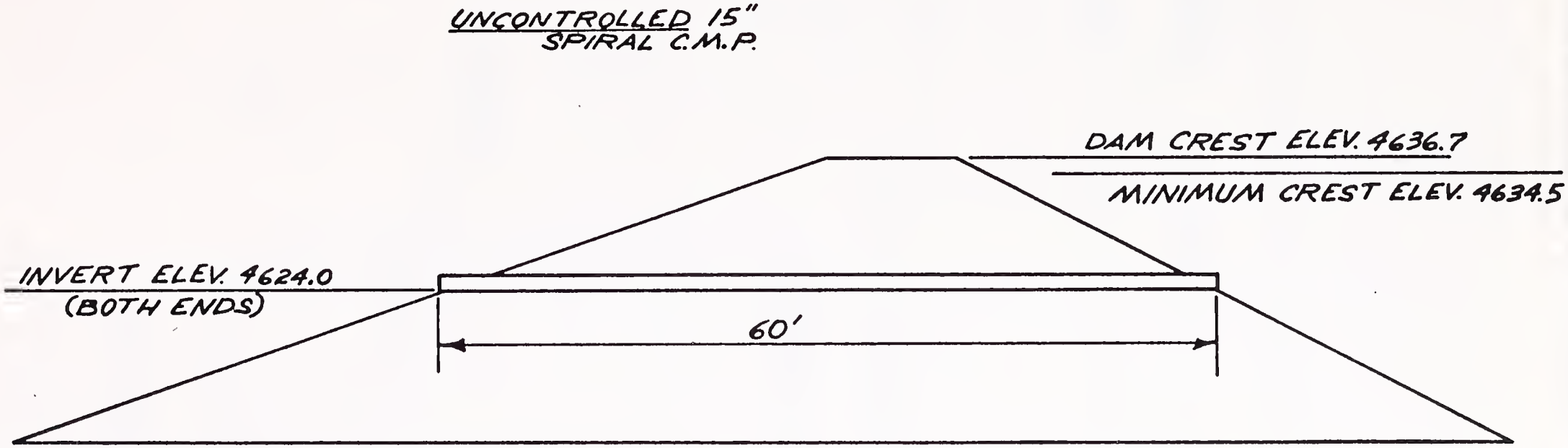
LOW LEVEL DRAW DOWN/OUTLET WORKS

SCALE 1" = 20'

PLATE 5

TWO DOT DAM

OUTLET WORKS

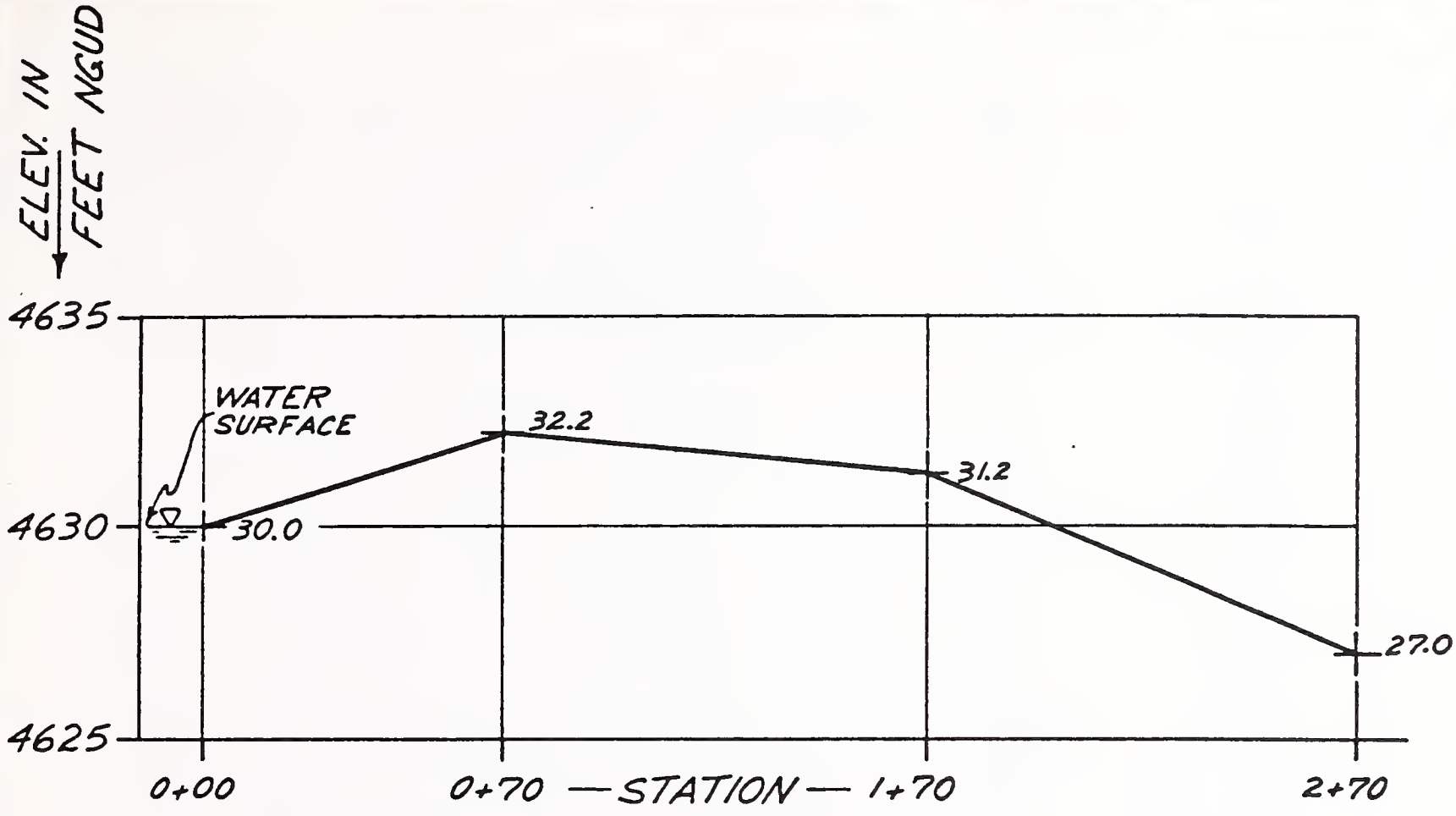


IRRIGATION OUTLET WORKS

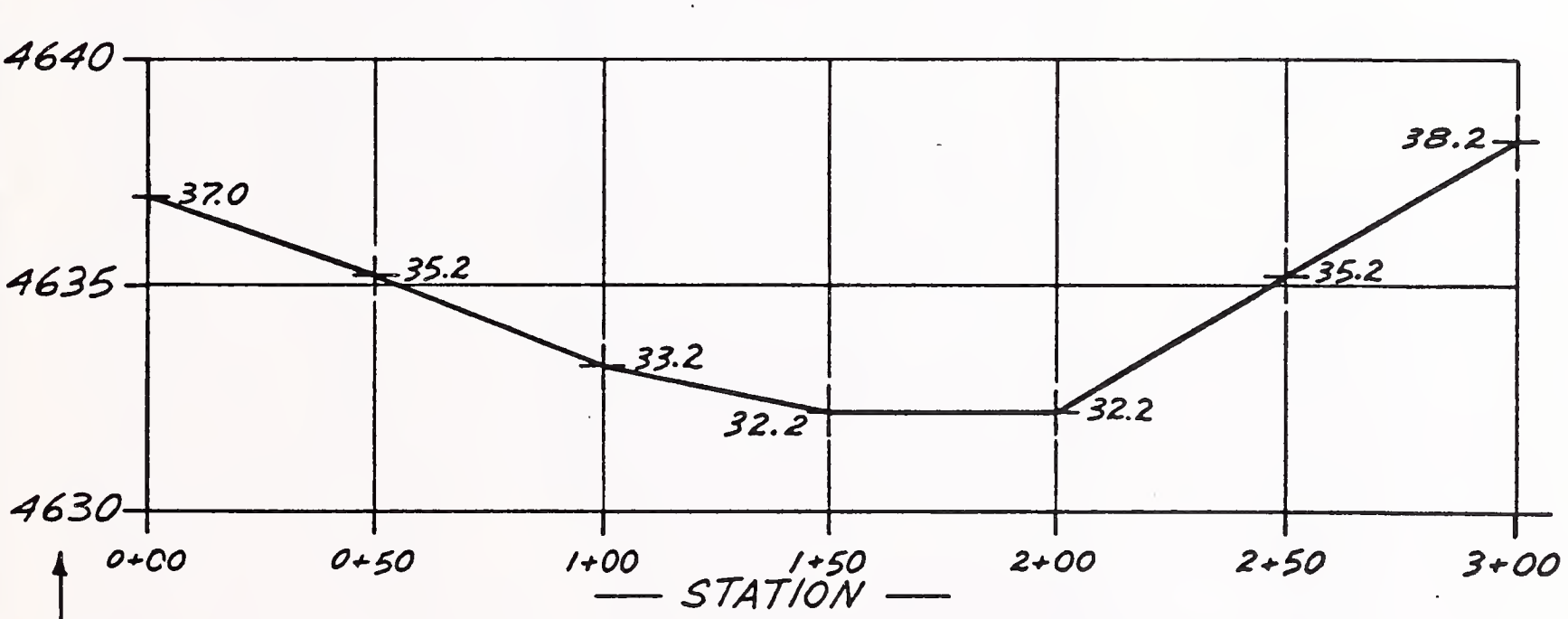
SCALE 1" = 20'

PLATE 6

TWO DOT DAM
IRRIGATION -
OUTLET WORKS



SPILLWAY SECTION



SPILLWAY PROFILE

PLATE 7

TWO DOT DAM

SPILLWAY

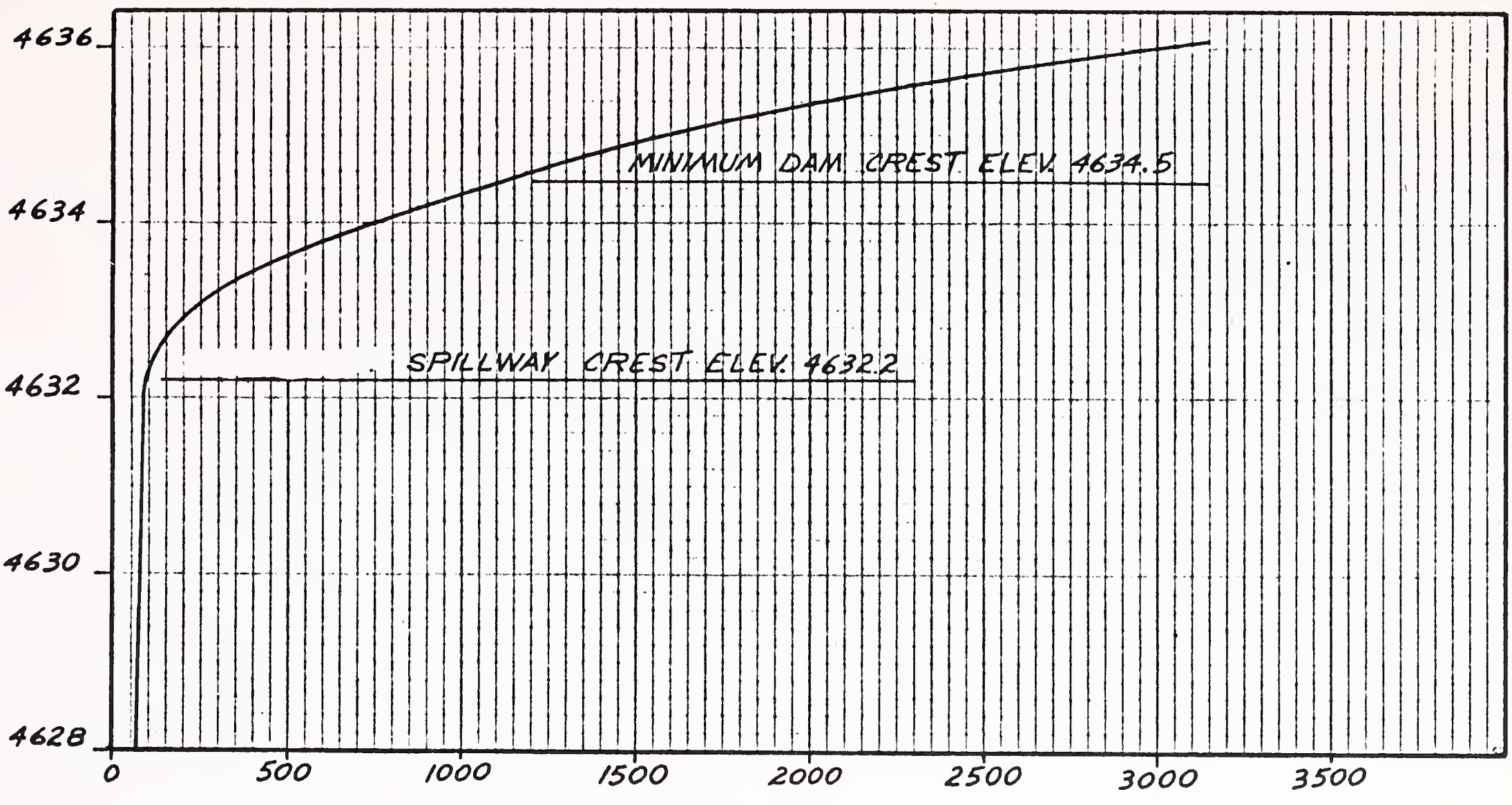


PLATE 8.

TWO DOT DAM

RATING CURVE

RATING CURVE FOR COMBINED SPILLWAYS

APPENDIX A

OWNER DID NOT RESPOND

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION

TED SCHWINDEN, GOVERNOR

32 SOUTH EWING

STATE OF MONTANA

(406) 449-2872 ADMINISTRATOR
(406) 449-3962 WATER RIGHTS BUREAU
(406) 449-2872 WATER SCIENCES BUREAU
(406) 449-2864 ENGINEERING BUREAU
(406) 449-2872 WATER PLANNING BUREAU

HELENA, MONTANA 59620

June 26, 1981

Ralph Morrison
Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, Washington 98124

Dear Ralph:

Re: Christian, Spring, Sielbach & Associates Dam Safety Inspection Report on Twodot Dam (MT-1486)

We have reviewed the above referenced final draft report. We concur with the findings and recommendations and find that it satisfies the criteria of the Phase I report.

Minor editorial comments have been discussed with your staff, and we understand these will be incorporated in the final report.

Thank you for the opportunity to review and comment on the final draft report on Twodot Dam.

Sincerely,

Glen J McDonald

for Richard L. Bondy, P.E.
Chief, Engineering Bureau

RB:AT:lz